Morphological study of the FeCo magnetic thin film fabricated by EBPVD

A.Azizi [1,2]*, S.K.Sadrnezhaad [1,2] and R.Eskandari

[1] Magnetic Nanomaterials Group, Department of New Materials, Materials and Energy Research Center, Tehran 14155-4777, Iran
[2] Department of Materials Science and Engineering, Sharif University of Technology, Tehran 11155-9466, Iran

Abstract-The present paper focuses on the synthesis and characterization of a narrow and homogeneous FeCo thin film prepared by electron beam physical vapor deposition (EBPVD). After optimizing the evaporation conditions, a narrow (~50 nm thickness) and uniform film with very fine particulates (~100 nm) which is suitable for magnetic recording head core applications was synthesized.

In recent years, there are growing requests for higher magnetic recording densities [1]. A magnetic recording head is a key device for achieving high-density magnetic recording, with soft magnetic thin films (having a high magnetic flux density (B) and low coercivity (Hc)) being used as core materials. Fe–Co based alloys can be a promising candidate for this purpose because of having a very high saturation magnetic flux density [1]. The present work deals with the synthesis and characterization of the FeCo thin film prepared by electron beam physical vapor deposition (EBPVD).

Mechanochemical process [2,3] was used to prepare the FeCo nano-powder which in turn going to be used as a target material for the thin film deposition. Analytical grade hematite (Fe2O3) (MERCK, Gmbh) was mixed with cobalt oxide (Co3O4) (MERCK, Gmbh) at the elemental Fe:Co molar ratio of 2:1. The mixture was milled at 350 rpm having ball to powder weight ratio of 20:1 for 20 hr. The produced Co-ferrite powder was then reduced with hydrogen at 750 °C.

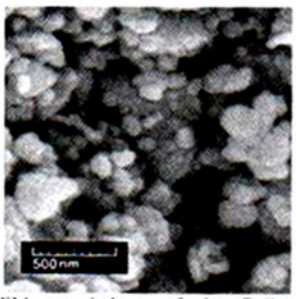

Figure 1. SEM morphology of the FeCo nano-powder synthesized by mechanochemical process

The SEM image (Figure 1) of the mechanochemically synthesized FeCo nano-powder reveals the morphology of the FeCo powder. The size of the Particles found ~60nm from the results.

FeCo thin film was prepared by an electron beam evaporation system with an initial vacuum (base pressure) of 2×10^{-6} Torr, an accelerating voltage of 3.5 kV. The synthesized FeCo powder was used as a target material for evaporation source. The samples were deposited on a silicon with (1 1 0) surface as the substrate. The substrate was set at a distance of 12 cm from the source. Thickness of the film (~50 nm) was controlled with the help of an in situ quartz crystal thickness monitor.

Figure 2 shows the 2D and 3D AFM images of the FeCo thin film. As is seen in the figure, the surface of the film is very uniform and the average size of its particulates was obtained ~100 nm by analysis of the 2D AFM image.

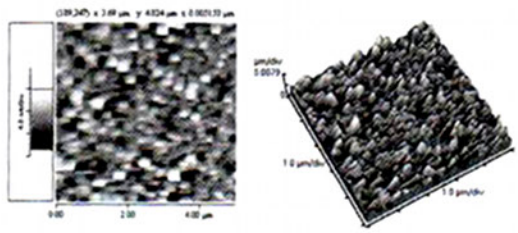

Figure2. The 2D and 3D AFM images of the FeCo film prepared by EB-evaporation process

Table 1. EDS analyses of the surface of the FeCo powder and film shown in Figure1 and 2.

	Fe (Atomic%*)	Co (Atomic%*)	Fe (Weight%*)	Co (Weight%*)
FeCo powder	68.03	31.97	66.85	33.15
FeCo film	72.83	27.17	71.75	28.25

*The amount of Si substrate and gold used for coating are excluded.

The surface of the powder and the film shown in Figure 1 and 2 were analyzed by EDS. The results of these analyses are given in Table 1. The data tabulated in the table indicates atomic and weight percentages of the elements have changed after EBPVD. This may be related to the nature of the EBPVD process, resulting in a stoichiometry that is different from the initial material [4].

The uniformity and average size of the particles have significant effects on magnetic properties of FeNiCo thin films. The particulate size should be small to favor a low value of Hc for the soft magnetic thin film, and these fine particulates with same crystalline structure should be homogeneously distributed, keeping the value of Hc low [5]. According to the results, a narrow and homogeneous film with fine particulates which is appropriate for magnetic recording head core materials was fabricated.

We thank Mr. H. Azizi and Mr. M.R. Hasanzadeh for fruitful helps.

*Corresponding author: azizi@alum.sharif.edu

[1] S. Ohnuma, N. Kobayashi, H. Fujimori, T. Masumoto, X.Y. Xiong, K. Hono, Scr. Mater. 48, 903–908 (2003).
[2] A. Azizi, H. Yoozbashizadeh, S.K. Sadrnezhaad, J. Magn. Magn. Mater. 321, 2729–2732 (2009).
[3] A. Azizi, S.K. Sadrnezhaad, J. Alloys. Comp. 485, 484–487 (2009).
[4] B.A. Movchan, Surf. Eng. 22, 35–46 (2006).
[5]T. Osaka, T. Asahi, J. Kawaji, T. Yokoshima, Electrochim. Acta 50, 4576–4585 (2005).